

An Image Processing based Raindrop Parameter Estimation

Ganesh kolte¹, P.A.Ghonge²

¹Lecturer, SESGOIFE, Karjat, India

²Principal, YTIET Karjat, India

Abstract: This paper deals with measurement of number of drop and its volume in a frame. We are using video to frame conversion so that we can calculate the amount of rain water in an particular time. This system found to be more accurate and errors free like spreading, evaporation of drops induced errors are neglected as this system uses image processing tool to make analysis of data. It involves many operations which performed on raw data collected from high definition camera. System response time is also less.

Keywords: raindrop count, raindrop volume, region bounding, metric.

I. INTRODUCTION

Rain is very important parameter on Earth and has much impact on life of living beings. Many techniques have been developed to measure the rain fall in given area or in particular terrestrial area; mainly for this precipitation Radars are used although Radar provides information accurately performance is limited by several errors. Many existing systems are there which only concentrate on drop distribution not on size and volume of drops. Many methods are used to calculate rain drop size and shape using image processing all are concentrating in image registration like using photometric raindrop model, eigendrops method etc. One of the main systems used for rain analysis are rain gauges but they have not so much accurate due to different losses incurred by them like Wind-induced errors, Evaporation and Wetting Losses this losses are overcome by this system. In our project, we will be using image processing techniques such morphological operations. We will detect the rain drop in the image where rain drops are present. Then the size of the drops is estimated assuming the spherical size of the rain drop using spherical volume formula. Total rain drops are calculated. Complete rain drop volume is calculated on the image frame. The input image set can be taken from 3D dataset. Its rain drop variations are shown on 3d plot using Matlab mesh grid analysis. The complete operations will be developed using Matlab software.

II. MORPHOLOGICAL OPERATIONS

In this project we have used a morphological operation to extract the vital information from collected data.

Following operations are used:

1. Dilation

2. Erosion
3. Opening
4. Closing

Above morphological operations are performed on data to get useful information which can be further used in analysis.

III. EXISTING METHODS

Measuring rain parameter is very old process previously this type of measurements was done using rain gauges which were popular methods. But now with advancement of technologies methods are changed because using gauges was not a optimum if we are looking to the accuracy of gauges the accuracy of any gauges depends on many factors like wind, light, evaporation this losses will result into false readings.

Types of gauges

- 1) Standard gauge
- 2) Tipping bucket gauge
- 3) Weighing rain gauge
- 4) Optical rain gauge
- 5) Parsivel-efdisdrometer

Above all gauges have their losses as said above like i) wind induced errors this loss is occur when drop is of very small size it will be lost due to wind and that drop is not collected in gauge ii) Second error is introduced due to evaporation this types of losses are observed in storage type gauges which counts a water by storing in tank where readings are taken after some days or in long duration. iii) Other errors are device problem if device is not calibrated accurately all reading will be false. So we can say that using image processing technique we can avoid these errors and system can give a better result than above all system.

IV ORGANIZATION OF PAPER

This whole paper concentrates on raindrop parameter measurement system using image processing which involves 5 section A,B,C,D and E in A section block diagram of system is discussed, while other discusses methodology, experimental results and conclusion, and future scope respectively.

A. IPRDPE (image processing based rain drop parameter estimation) SYSTEM

Main purpose of this system is to calculate the number of drops present in given picture frame and volume of that counted raindrops in an image. Rain drop can be of different sizes and shapes but in our system mainly focuses on spherical shapes drops and

calculates the volume for those raindrops using spherical formula for sphere. Those rain drops are not of spherical shapes by default are considered as non spherical and that volume also gets counted in total volume. In this system we have used morphological operations on an enhanced and filtered image like edge detection, pattern recognition techniques are used. System block diagram is given below which is having many stages as shown.

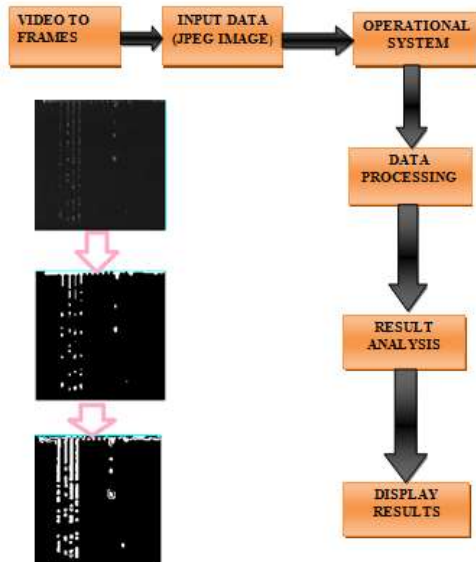


Fig.1 Block diagram of IPRDPE system

Systems working can be explained by considering working of each block.

1) Video to frames conversion:

In this stage input video which is taken from high definition camera is converted into frames. So that frames can be used as an image in further processing., frames are stored as JPEG format other formats can also be used.

2) Input Data:

Input data means input image that we have to use in further processing, input image are taken from previously got frames from video to image conversion this video from high definition camera directly and that image can be in any format and any colour.

3) Operational System

The system is a computer with minimum 500 GB storage place where all the data is processed and the analysis is done on the data provided by the camera. MATLAB software is used as base to find out the raindrop size count and total raindrops volume in mm. Matlab version R2013a is used with advance functions.

4) Data Processing:

Data processing block involves the operations that are performed on input data which is an image of

raindrops. Following operations are performed on an image to get desired results.

- a. RGB to Gray conversion
- b. Image scaling
- c. 3D mesh
- d. Image Filtering
- e. Quality Enhancement
- f. Region Bounding
- g. Raindrop analysis

5) Result analysis:

Result analysis block deals with gathering the data collected in raindrop analysis process like calculating total number of spherical non spherical raindrops. It gives information of total volume present in frames and total drops present that can be of any shapes. As we have used video to collect the frames and then that frames are used as images to have further processing we are able to say that we can calculate the amount of water present in a particular video. So in this stage system gives frame wise drops and volume. To get total volume we have add these results.

6) Display Results:

Results got in early stages are displayed in this stage. Number of drops in each frame and volume per frames are displayed on GUI. We have graphical relationship between number frames vs total volume, total drops. Similarly we have plotted a graph between frames and individual Pearson coefficient value.

B. METHODOLOGY

This section explains the algorithm of *IPRDPE system*, Which involves various process that are performed on raw data image to get results means calculating the number of drops and total volume of water in given image provided image must of some good quality. this algorithm can be explained by following figure below,



Fig.2 Operational algorithm of IPRDPE system

This algorithm can be explained by following steps:
Step 1: Select Raindrops Image

In this image is selected for further processing.

Step 2: Image scaling

The selected image is scaled to [256 256] to make standard size.

Step 3: Image histogram

Histogram of resized image is calculated in stage we come to know the intensity variations in frames which can be used further processing.

Step 4: 3D mesh image

This step gives 3D view to input image.

Step 5: Image filtering

In stage Gaussian and median filtering is applied so that image response becomes smooth and all noises like paper n salt are removed and will get noise free image so that further processing will be accurate and noise free. Median filter is used to reduce salt and pepper noise which is recognized by black and white spots on image this noise can be inherently reduced by the use of median filter. As we are also we have used m-canny edge detection technique to trace the boundaries of raindrops. In this technique Gaussian filtering is first stage.

Step 6: Image quality enhancement

In this stage the Otsu thresholding method is used to enhance the quality of image in our context. Due to thresholding the image will be divided into two classes as background and foreground. So in our interest drops are highlighted from background so we can easily count them and apply different techniques to achieve our goal. Let we have two classes as C1 and C2 so e have to count the number of pixel that fall under each category for that we have to calculate probabilities of each class.

Probabilities of individual class can be calculated as,

$$P_1(k) = \sum_{i=0}^k P_i \tag{1}$$

$$P_2(k) = \sum_{i=k+1}^{L-1} P_i = 1 - P_1(k) \tag{2}$$

Mean intensity value for pixels under C_1 ,

$$m_1(k) = \frac{1}{P_1(k)} \sum_{i=0}^k iP_i \tag{3}$$

Mean intensity value for pixels under C_2

$$m_2(k) = \frac{1}{P_2(k)} \sum_{i=k+1}^{L-1} iP_i \tag{4}$$

Average intensity of the entire image that is global mean is given by ,

$$m_G = \sum_{i=0}^{L-1} iP_i \tag{5}$$

$$\sigma^2_B(k) = \frac{(m_G P_1(k) - m(k))^2}{P_1(k)(1 - P_1(k))} \tag{6}$$

The optimum threshold will be value of k^* for which maximizes the

$$\sigma^2_B(k^*) = \max_{0 \leq k \leq L-1} \sigma^2_B(k) \tag{7}$$

Once k^* is calculated image will be segmented as ,

$$g(x, y) = \begin{cases} 1 & \text{if } f(x, y) \geq k^* \\ 0 & \text{if } f(x, y) \leq k^* \end{cases} \tag{8}$$

K is the threshold value which is the value of k for which the interclass variance $\sigma^2_B(k)$ will be maximum.

Algorithm for Otsu is given below:

1. Compute normalized histogram
2. Compute probabilities of each intensity level
3. Set initial $P_i(0)$ and $m_i(0)$
4. Compute global intensity mean, m_G
5. Compute interclass variance σ_B^2
6. Compute Otsu threshold, k^* , as value of k for which σ^2_B is maximum. If the maximum is not unique then obtain k^* , by averaging the values of k corresponding to the various maxima detected.

Step 7: Region bounding

In this stage raindrops are detected using different morphological operations, raindrops can be identified by using following steps:

1. Rain drop detection using ROI

In this stage first threshold is find out then using that threshold value image is converted to binary image. Due to that conversion raindrops are highlighted from background as shown

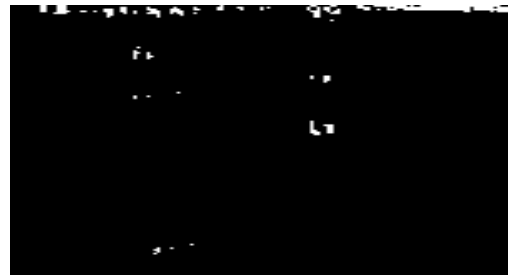


Fig.3 Rain drop detection using ROI

2. Extract rain drop objects using pattern recognition approach

In this step raindrops are extracted using pattern recognition approach; following steps are involved in extracting raindrops from an image.

- First morphological operator is applied. So we get an image in which objects are highlighted.
- By applying canny detectors edges are find out.
- Disk shaped structuring element is generated.
- Dilate that edge detected image with this disk shaped element.
- Fill the holes in dilated image.



Fig.4 Processed image

Step 8: Rain drop analysis:

The rain drops can take either spherical or non spherical sizes. We are considering both objects. The objects are determined by using image morphological operations. The sphere object is determined by the formula and other objects are treated as non spherical. The results may vary from image to image and also vary from the actual drop. Following steps are involved:

- Using grayscale image that we got previously and morphological operation we remove very small objects by defining a certain threshold let in our case is 5.
- Then processed image is again dilated with disk shaped structuring element.
- Morphological closing is applied.
- Filling holes in obtained image.
- Tracing boundaries of desired objects for tracing canny edge detection is used.
- Apply loop over boundaries.
- Compute metric(volume) using formula:

$$\text{Metric} = 4 * \pi * \text{area} / \text{perimeter}^2$$

Where, $\text{area} = \text{stats}(k).\text{Area};$
 $\text{delta_sq} = \text{diff}(\text{boundary}).^2;$
 $\text{Perimeter} = \text{sum}(\text{sqrt}(\text{sum}(\text{delta_sq}, 2)));$

- By using certain threshold in our case we have taken 0.64 compare obtained volume with threshold if it is greater than threshold value count that drop as spherical and below as non spherical.

- Total count of drops and total volume is calculated as,
 - total volume=volume of spherical +non spherical drops
 - Total count of drops=no of spherical +non spherical drops
- Results are displayed in addition with volume and total count of drops present Pearson coefficient and image quality index are also shown.
- Final results are also graphically plotted so that we can see overall rain data.

C. EXPERIMENTAL RESULTS

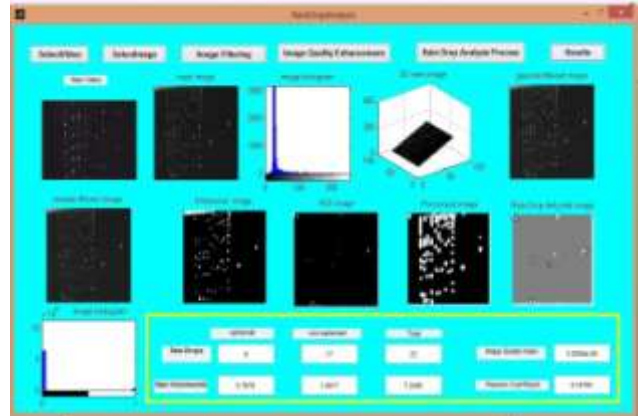


Fig.5 Final results of rain image

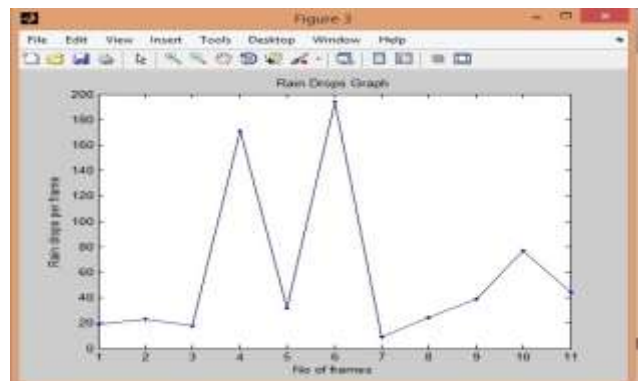


Fig.6 Number of drop vs number of frames

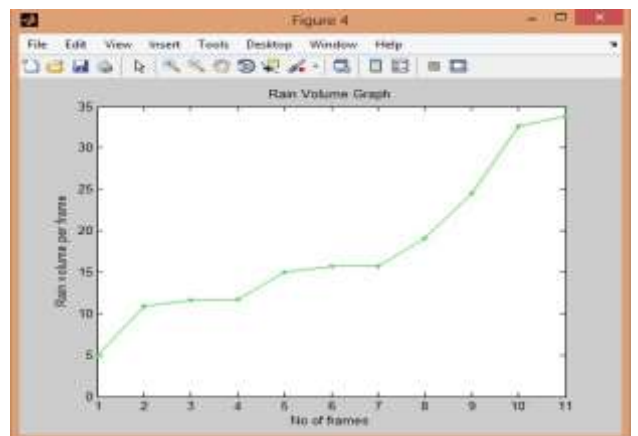


Fig.7 Total drops volume per frame vs number of frames

D. RESULT and CONCLUSIONS

Rain plays very important role in human's life so its measurement results will be more important, in this system we mainly dealing with a) Raindrop counts in frames and b) Total volume associated with each frame. As we have considered video to frame conversion we got 11 frames by adding all results of 11 frames we can calculate total rain in video. So we can predict a rain in particular time. Selection of threshold value for morphological operation is very important in our case we have taken 0.64 values which gives optimum results in our case.

As we are counting raindrop and its volume before touching the ground surface our analysis is more accurate because errors like spreading of drops, evaporation, losses, wind induced errors are not affecting our calculations.

As this system uses image processing tool to perform analysis it is cost effective solution to raindrop parameter estimation and can be used in many applications like public warning systems, rain prediction systems.

E. FUTURE SCOPE

Since the performance of this project depends on selections of optimum threshold we will find possible method to select threshold values which will improve accuracy of system. In future we are planning to analyze live rain data so that this can be generalized and can be publically implemented. In this project data used is 2D we can improve the results by considering 3D data set.

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